

Evaluation of Newly-developed Blackcurrant Cultivars in Dry Zone of Buryatia

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Blackcurrant is one of the most highly-valued fruit crops in the Republic of Buryatia. Most of blackcurrant varieties from nonspecific geographical areas are worse-adapted to local soil-climatic conditions. Hence, breeding and fruit variety studying along with assessment of its agronomic traits are crucial for the further recommendation of fruit cultivation in the region. The goal of the study is to reveal the availability of better-adapted varieties and enlarge the assortment with new cold tolerant cultivars offering improvements in fruit quality and resistance to diseases.

Key words: Blackcurrant, Selection, Hybridization, Cold tolerance, Self-fertility, Self-pollination, Biochemistry.

In recent years there has been an increased scientific interest to blackcurrant (*Ribesnigrum* L.) within the *Ribes* genus due to the perceived health benefits associated with the consumption of vitamins, minerals, dietary fibre, and other bioactive constituents (Brennan, 2008; Bakowska-Barczak and Kolodziejczyk, 2011). As a source of bioactive components such as phenolic acids, flavanols, flavonols, tannins, particularly anthocyanins being natural antioxidants, blackcurrant like other berry fruits was best known in many studies as natural functional food since the years 2000-2004 (Hakkinen and Torronen, 2000; Wang and Lin, 2000; Connor *et al.*, 2002; Hakala *et al.*, 2003;

Skupien and Oszmianski, 2004; Taruscio *at al.*, 2004). Because of *Ribes* healthwise the USA that did not previously cultivate the crop, feels deep concern about expanding production (Hummer and Dale, 2010). In Russia and especially in the Eastern Siberian extreme climates blackcurrant cultivation is a modern breeding programme providing human diets with a fresh fruit that is rich in high source of AsA. In particular, the proven high AsA levels in the fruit being an important attribute of the crop, and to a larger extent, the content of bioactive substances increase specific demand for new cultivars improved in yield and fruit quality (Brennen and Graham, 2009; Bakowska-Barczak and Kolodziejczyk, 2011; Vagiri, 2012). While health benefits, high yield remain of key importance to fruit growers, processors and consumers, there is a growing interest in improving other agronomic characters in blackcurrant cultivars such as cold hardiness, early ripening of the fruit that promote to their

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large-scale commercial and amateur cultivation (Nazaryuk and Baranova, 2007). Therefore, it is vital to study and introduce new and economically valuable cultivars of domestic and foreign selections able to adapt to local climates and for commercial purposes (Zabelina and Nakvasina, 2007). Although the main emphasis is given to the revealing varieties with high level of agronomic characters, content of bioactive components and higher quality of fruit; selection and classification of starting material, and further examination of its donor traits are equally important for finding solutions in selection and breeding (Sokratova *et al.*, 1993). Renewal of the assortment with better cold tolerant, disease resistant, large-fruited, early-ripe, self-fertile, drought-resistant cultivars with high content of bioactive substances is becoming an important factor in the development of economically valuable cultivars in the Eastern Siberia (Shiripnimbueva *et al.*, 2010). In the context of improving agronomic characters in cultivars the study suggested to use Siberian blackcurrant subspecies and dikuscha currant for the further identification of their best performance and cultivation in private gardens and commercial farms, and their further application in the selection and breeding programmes (Voronina, 1996).

METHODS

Development of new cultivars and fruit hybrids was made through interspecific hybridization followed by multiple step crossbreeding (saturable cross), backcrossing and distant hybridization (Kobyakova, 2012). Trials are carried out in accordance with the programme and methods on variety study in fruit crops (Programme and study methods..., 1970), programme and breeding techniques in berry crops and nut-fruited crops (Programme and techniques..., 1995), programme and methods on variety study in berry crops and nut-fruited crops (Programme and methods..., 1999).

Preferably frost tolerant cultivars, assorted wild species, and assorted Buryat research institute species of the first, second and third hybrid dominance including *R. nigrum sibiricum*, *R. ssp. dikuscha*, *R. nigrum ssp. Europium* were used as parent materials. The

hybrid nursery stock was planted at 3,0 and 1,0 metre spacing, and 3,0 and 1,5 metre apart in rows. Because black currant is an early spring blooming shrub, winter hardiness in hybrids was assessed after critical winter temperatures. Assessment of restoration capability was based on overall shrub condition in autumn after winter freeze damage (Salikova, Sankin, 2007). All these efforts were made to develop less affected by weather conditions cultivars; the more stable a cultivar is, the more amenable it is for commercial processing (Zheng *et al.*, 2009).

Natural self-fertilization combined with bushing pollination, artificial pollination (pollen fertilization in certain selected varieties) and open pollination (control) were used to study a degree of self-fertility in cultivars and select one of the best pollinating varieties (Ogoltsova, Knyazev, 1997). To measure crop productivity in blackcurrant cultivars we assessed the weight of harvested fruit out of separate shrub and the whole fruit plantation. The average weight was calculated by weighing 100 berries (Zotova, 1983). Biochemical analysis was conducted in the Laboratory of Centre of Standardization, Metrology and Certification in the Republic of Buryatia (Prokofyeva, Platonova, 1980). The experiments were carried out on field sites with typical eastern siberian dry steppe climates by the department on selection and propagation of fruit and berry crops of Federal State Budgetary Scientific Institution "Buryat Research Institute of Agriculture".

Research results

Biological assessment of cultivars

Blackcurrant of Buryat assortment is extremely tolerant to frost, and flower buds do not damage after winter season. Low-temperature resistance has a complex genetic basis recognized as one of the important agronomic traits; thereby it is an essential indicative of cultivar adaptability (Lobanov, Kurochka, 1980). Blackcurrant cultivars may pass harmed and subfrozen as a result of untimely finished vegetation, inappropriate hardening off period, and poor preparation for wintering. Indigenous blackcurrant species are best known for high tolerance values, particularly such cultivars as "Zabaykalochka", "Gaykhal", "Beryozovka", "Voroninsky", "Tona", "Yanzhay", "Speranta". One of the key factors of higher crop

yields in blackcurrant is fruit setting through self-pollination (Astakhov, 1981). Self-fertile capability allows a variety to bear fruit under unfavourable temperatures during flowering season, when pollinating insects are sluggish and inactive. Capability to set fruit after artificial pollination is likely to define a degree of self-fertility and ability to set a fruit in similar plantations in actively running bees and insects when pollen from other shrubs of the same variety. In bad weathers cross-pollination during flowering is hardly ever possible, as it can cause unfertilized fruit drop and increase a risk of fruit yield loss, particularly in more affected varieties (Kalinina, 1981). Productive potential of one variety is directly correlative to its self-fertility. There appears to be a positive correlation between a berry size and self-fruitfulness derived from the same parents, i.e. the more fruit with a consistent shape and much more solid cluster, the more is the ability to self-fruitfulness (Knyazev and Ogoltsova, 2004). Most self-fruitful cultivars are dikuscha blackcurrant offshoots used in various cross

combinations with european siberian subspecies (Zabelina, 1999). Buryat cultivars bred in harsh climates and dry steppe zones are blackcurrant species with good genetic materials and excellent agronomic characters including high adaptability, tolerance to low temperatures, self-fruitfulness and higher yielding capacity. Newly-developed cultivars show a high level of self-fertility. In open pollination 80 percent of most self-fertile species are "Gaykhal", 75 percent is "Beryozovka", 53 percent – "Voroninsky", 84 percent - "Tona", 87 percent – "Yanzhay", while in other species a self-fertile exponent is between 45 and 65 percent (Guseva, 2005). Gross fruit weight in most self-fertile cultivars ranges between 1,8 and 2,2 g, with maximum of 2,2 and 3,8 g (Table1). Gross fruit weight in most self-fruitful species is between 1,8 and 2,2 g with maximum of 2,2 and 3,8 g (Table1).

The growth of blackcurrant for fresh market is rather associated with the improvement of fruit crop and agronomic practices for much higher consistent yields than extension of

Table 1. Self-fertility in blackcurrant cultivars

Cultivar	Pollination					
	Natural		Artificial		Open	
	Fruit-set, percent	Gross weight, percent	Fruit-set, percent	Gross weight, percent	Fruit-set, percent	Gross weight, percent
Voroninsky(control)	53	1,8	78	1,9	53	2,2
Zabaykalochka	46	2,0	76	2,2	63	2,4
Beryozovka	45	1,9	76	2,2	75	2,2
Tona	64	2,4	76	2,6	84	2,6
Yanzhay	71	2,6	68	2,8	87	3,6
Gaykhal	80	2,2	69	2,2	80	2,2
Tamir	53	2,1	79	2,1	87	2,2
Speranta	65	2,8	70	2,8	79	3,8
Nadeinka	60	2,4	68	2,2	84	2,2
Podarok Kalininoy	65	2,6	78	2,6	87	2,6

cultivated areas for cropping (Ravkin, 1987).

Blackcurrant grown in Buryatia is an early-ripe fruit, which is normally expected to set a fruit in the second year after planting, and as a result of good cropping practices it is able to produce no less than 2 tons per hectare. Potential production efficiency depends on good agronomic practices and genetic cultivar characteristics (Voluznev, 1968). Qualitative assessment of blackcurrant productive performance allows to

compare biological potential to fruit-bearing and its actual yield in the course of crop variety testing, and also to reveal provisions for the improvements in yield (Kuminov, 1983). Fruit-bearing of currant species is directly dependent on biological structure of a shrub (Work programme..., 2011). Fruit is borne primarily on three-year-old and four-year-old shoots, i.e. 33,0-42,8 percent is on three-year-old shoots and 20,2-28,2 percent is on four-year-old shoots. Such cultivars as

“Zabaykalochka”, “Voroninsky”, “Tamir” and “Beryozovka” stand out for their fast-growing capabilities. Fruit on five-year-old shoots is relatively low amounting to 11,9 and 12,8 percent (Guseva, 2009). Dry fruit harvesting is common to all blackcurrant species. Fruit in every cluster is of consistent shape. The cultivars studied are considered to be large-fruited, and gross fruit

weight ranges between 2,0 and 2,2 g, and the highest possible is 2,2 and 3,8 g (Table 2).

Biochemical and technological characteristics

Overall biochemical composition in blackcurrant is dependant not only on a variety and cropping season, but weather conditions, shrub arrangement in a testing site, age of cropping and universal agronomic practices.

Table 2. Characteristics of fruit quality in blackcurrant cultivars

Cultivar	Fruit weight, gr		Cluster length, sm	Taste, score
	average	maximum		
Voroninsky(control)	2,0	2,2	5,0-7,0	4,9
Zabaykalochka	2,0	2,4	6,0-8,0	4,4
Beryozovka	2,0	2,2	5,0-6,0	4,7
Tona	2,2	2,8	6,0-8,0	4,6
Yanzhay	2,2	3,6	7,0-10,0	4,8
Gaykhal	2,0	2,4	5,0-6,0	4,3
Tamir	2,0	2,2	7,0-9,0	4,8
Speranta	2,2	3,8	6,0-7,0	5,0
Nadeinka	2,0	2,8	6,0-8,0	4,8
Podarok Kalininoy	2,0	2,8	7,0-9,0	4,9

Varieties of diverse origin are different in chemical composition (Bichkauskene, 1981). A berry fruit originated from european subspecies is distinguished by unchanging chemical structure and high content of ascorbic acid (Franchuk, 1961). A berry fruit descended from dikusha currant is best known for average sugar content, ascorbic acid and other ascorbic acids, and lower content of soluble solids (Muravyeva and Muravyev, 2012). In dry and hot temperatures sugar and AsA accumulations are involved more intensively than in subhumid ones (Vigorov, 1972). Content of solids in berry when ripening ranges between 11, 8 and 14, 1 percent by a variety from year to year depending on weather conditions. High content of sugar is likely to occur in dry year, and it ranges between 8, 9 and 10, 8 percent by a variety. Actual acidity also varies between 1, 67 and 3,36 percent from year to year due to diverse weather conditions. Concentration of vitamin C varies by year, for instance it is more in dry season than subhumid one. Every buryat cultivar contains high level of vitamin C in berries that is 122,4 and 194,1 mg per 100 g. It is found to contain vitamin ranging between 315 and 556 mg per 100 g. The content of soluble pectin amounts to 0,42 and 0,74

percent (Table 3).

All buryat blackcurrant cultivars are high value food raw materials for processing industries, mainly to be used in the production of jam, stewed fruit and juices. A fruit maker judgment of these foods is between 4,4 and 5,0 grades. The cultivars have a long-term resistance to powdery mildew and are less susceptible to gall mite (Shevkunova, 1980).

Description of newly-developed cultivars Zabaykalochka

A cultivar is obtained by crossing hybrid of 2-50 local wild blackcurrant with “Primorsky champion”. It is a medium-size sprawling shrub, mostly 1,2-1,5 metre high. It is cold hardy, early ripe and an excellent self-fertile variety. Full maturity is highest in July 25-August 5th. While mature a fruit is 4-11 shiny berries borne in clusters, and gross fresh fruit weight is 2.0 g with a maximum fruit weight of 2.4 g. The flesh is juicy, and provides an excellent aromatic flavor. It is a non-shattering shrub and is used for all practical purposes. Average yield per bush is 1.5 kg with a maximum yield of 8 kg, its yield in the industrial garden is 10 tons per hectare. It is resistant to powdery mildew, blackcurrant reversion disease,

Table 3. Biochemical composition of fruit in blackcurrant cultivars

Cultivar	Soluble solids, percent	Actual acidity, percent	Sugar amount, percent	Soluble pektin, percent	Vitamin, mg/100g	
					C	P
Voroninsky(control)	11,8	1,67	10,0	0,49	186,1	418,0
Zabaykalochka	13,0	2,26	8,9	0,42	174,3	513,4
Beryozovka	14,1	1,98	9,0	0,68	122,4	344,1
Tona	13,8	2,01	9,6	0,60	186,6	423,4
Yanzhay	13,6	2,20	8,9	0,54	189,3	426,3
Gaykhal	13,8	3,36	8,9	0,42	174,1	389,9
Tamir	13,9	2,28	9,1	0,49	183,4	448,4
Speranta	14,1	1,98	10,8	0,74	194,1	556,0
Nadeinka	12,6	1,87	10,0	0,72	189,4	498,4
Podarok Kalininoy	12,8	1,67	10,8	0,68	156,9	389,9

and in some years it is slightly damaged by currant gall mite and spider mite. Its advantage is high winter hardiness.

Gayhal

It is obtained by crossing cultivars “Primorsky champion” and “Selenga”. A shrub is large-sized and poorly sprawling with large and yellowish-green leaves. It is the best cold-hardy, early ripe and an excellent self-fertile variety. Ripening is highest in July 25th-August 5th. Average yield per bush is 5 kg with a maximum yield of 9 kg, its yield in the industrial garden is 10-14 tons per hectare. While mature a fruit is large, shiny, black, toughed skin berries occurring medium in clusters. Gross weight is 2,2 g with a maximum fruit weight of 2,4 g. The fruit provides an excellent sweet-sour taste and aromatic flavor. The fruit drops a little, and its picking is dry. It is used for all practical purposes. It is resistant to powdery mildew and currant gall mite. Its advantage is large-fruitiness.

Beryozovka

It is obtained by crossing cultivars “Pushistaya” and “Omsk-2”. A shrub is large-sized and medium-sprawling with dark-green leaves. It is the best-known cold-hardy woody shrub, namely it is excellent for its bad winter hardiness, as well as early ripe and best self-fertile woody shrub. Average yield is 5 kg per shrub, and its yield in the industrial garden is 10-12 tons per hectare. It ripens in July 25th - August 5th. While mature a fruit is black, shiny berries borne in dense clusters with glandular dots on skin. Gross mass is 2,0 g with a maximum gross mass of 2,2 g. The

fruit provides quite a sweet taste, and delicate aromatic flavor. Its advantages include long clusters and upright growth.

Voroninsky

It is obtained by crossing cultivars “Pamayt Lisovenko” and “Zabaykalochka”. It is a large vigorously growing, compacted and medium-size sprawling shrub. It has dark-greenish leaves, and small at the top of shoot. This variety is cold hardy, early ripe and heavy self-fertile. Full maturity is highest in July 25th-August 5th. Average yield per bush is 3 kg, and the yield in the industrial garden is 11-12 tons per hectare. While mature it is 8-12 fruits borne in long clusters as big black and shiny berries with medium toughed skin. Gross fresh fruit weight is 2,0 g with a maximum fruit weight of 2,2 g. It has a sweet taste and delicate aromatic flavor. It serves to all practical purposes. Its advantages are large-fruit and aromatic flavor of berries (Pomology..., 2009).

Tamir

It is obtained by crossing cultivars “Buraya Dalnevostochnaya” and a lucrative hybrid 02-03-77. It is a large vigorously growing and medium-size sprawling shrub with large leaves, and smaller and densely growing dark-green leaves at top of the shoot. This variety is cold hardy, early ripe and heavy self-fertile. Full ripening is highest in July 25th - August 5th. Average yield per bush is 3 kg, and the yield in the industrial garden is 13 tons per hectare. While mature it is 8-12 fruits borne in long clusters as medium black and slightly shiny berries with medium toughed

skin. Gross mass is 2,0 g with a maximum gross mass of 2,2 g. The fruit provides a sweet-sour taste and aromatic flavor, and its picking is dry. It is used for all practical purposes. It is resistant to currant gall mite and powdery mildew. Its advantage is high yield (State Register, 2014).

Tona

It is obtained by crossing cultivars “Berdchanka” x “Gorhon”. It is a large vigorously growing and medium-size sprawling shrub with medium bushiness. The leaves are large and dark-green. It is cold hardy, early ripe and a heavy self-fertile woody shrub. Its flowers are resistant to late spring frosts. Full maturity is highest in July 25th-August 5th. Average yield per bush is 4,5 kg with its maximum of 9 kg, and 12-14 tons per hectare in the industrial garden. A fruit is borne in medium clusters. While mature a fruit is big, black and medium shiny berries with thin skin. Gross fresh fruit weight is 2,2 g with a maximum fruit weight of 2,8 g. Its flesh is tender, and provides an excellent aromatic flavor. Picking of berries is dry. Its advantages include high yield and large-fruitiness.

Yanzhay

It is obtained by crossing cultivars “Velyur” x “Gorhon”. It is a large vigorously growing and medium-size sprawling shrub with large green leaves. It is cold hardy, early ripe and an excellent self-fertile woody shrub. Full ripening is highest in July 25th - August 5th. Average yield per bush is 5 kg with its maximum of 9,5 kg, and in the industrial garden it is 13,5 tons per hectare. A fruit is borne in medium clusters. While mature a fruit is big, black and shiny berries with a thin skin. Gross fruit weight is 2,2 g with a maximum gross fruit weight of 3,6 g. A fruit provides a sour-sweet taste and aromatic flavor. Picking of berries is dry. Its advantages include large-fruitiness and excellent winter hardiness.

Speranta

It is obtained by crossing cultivars “Titania” x “Zabaykalochka”. It is a large vigorously growing and medium-size sprawling shrub with large, dark-green leaves. It is cold hardy, early ripe and an excellent self-fertile woody shrub. Average yield per bush is 9 kg, and in the industrial garden it is 14 tons per hectare. It has a medium maturity time span, and a full ripening

is highest in July 25th- August 5th. A fruit is borne in medium clusters densely arranged. While mature a fruit is black and shiny berries with a thin skin. The fruit provides a delicate and aromatic aroma. Gross mass is 2,2 g with a maximum gross mass of 3,8 g. It is a slightly shattering shrub, and it bears fruit at the second and third years. It serves to all practical purposes. It is resistant to currant gall mite and powdery mildew. Its advantage is high yield.

Podarok Kalininoy

It is obtained by crossing cultivars “Sayana” x “Berdthrop”. It is a large vigorously growing and medium-size sprawling shrub with large, light-green and savoyed leaves. A variety is cold hardy, early ripe, self-fertile and large-fruited. Average yield per bush is 7,5 kg, and in the industrial garden it is 11 tons per hectare. It has a medium maturity time span, and a full ripening is highest in July 25th - August 5th. A fruit is borne in medium clusters densely arranged. A fruit is black and shiny berries with a moderate skin. The fruit provides a sour-sweet taste, a delicate and aromatic flavor. Gross fresh fruit weight is 2,2 g with a maximum fruit weight of 2,8 g. The variety bears fruit at the second and third years. It serves to all practical purposes. Its advantages include high yield and winter hardiness.

DISCUSSION

Many blackcurrant varieties are directly descended from wild species of siberian subspecies and dikusha currant that are found to stand out among other varieties in terms of high yield, large fruit and cold tolerance (Ogoltsova and Knyazev, 1995). Indigenous blackcurrant species are defined by high potential to cold hardiness. The study indicates that testing cultivars show different levels of self-fertility and self-pollination. A fruit-set is higher in artificial and open self-pollinations than in natural one. Although many currants are self-fruitful, yield is many times greater in mixed-cultivar plantings. The most essential genetic value in any species is its ability to preserve relatively unchangeable biochemical structure in various growing environments (Bochkarnikova, 1973). Large fruit is typical to siberian blackcurrant species, especially its reddish black shape. This attribute is

securely released to offshoots in cultivars “Zabaykalochka”, “Speranta”, “Gaykhal”, “Yanzhay”, “Tona”. The length cluster attribute is peculiar to both “Yanzhay” and “Podarok Kalininoi” cultivars. High yield potential is released to the offshoots in cultivars “Gaykhal”, “Yanzhay”, “Tamir”, “Tona”. As it can be seen from the above, breeding programme involves cultivars with complex genetic background. It shows that with regard to efficient breeding scheme economically valuable cultivars are “Gaykhal” and “Beryozovka” due to offering best improvements in yield. The study suggests crop breeders to use interspecific or distant hybridization as a new breeding objective and so a sustainable method of increasing genetic diversity and conserving genetic material for the future generations.

CONCLUSION

As a result of longstanding fruit crop breeding and genetic resource study well-known crop breeders of Federal State Budgetary Scientific Institution “Buryat Research Institute of Agriculture” successfully demonstrated possibilities to develop indigenous cold hardy and drought tolerant blackcurrant cultivars offering a set of agronomic characters. Use of better-adapted varieties of siberian and european blackcurrant species including hybrid descendents of the best domestic and international variety-donors in the breeding programme promotes to the further development of cultivars environmentally adaptable to biotic and abiotic stress, and increase high economic efficiency of fruit crop production in the Eastern Siberia.

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